Modeling New York City impacts on Long Island weather during a heat wave

L. E. Ortiz[1], W. Wu[2], J. Gonzalez[1], R. Bornstein[3], M. Schoonen[2], and J. Tongue[4]

[1]Mechanical Engineering Department, City College of New York
[2]Environmental & Climate Sciences Department, Brookhaven National Laboratory
[3]Department of Meteorology, San Jose State University
[4]NOAA/National Weather Service, Upton, NY

August 8, 2014

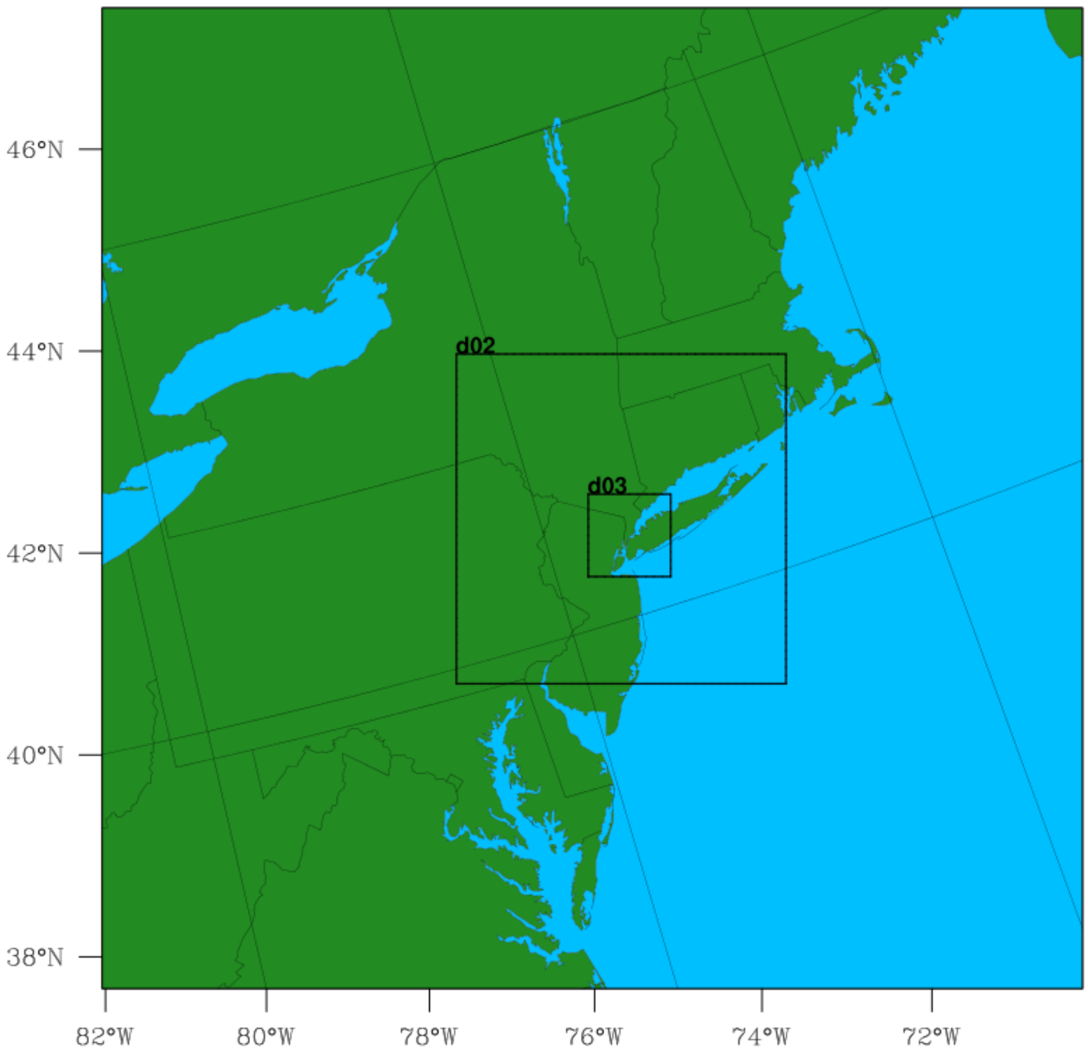
Introduction

- **Extreme weather events have impacts on human health and infrastructure.**
- **These effects are exacerbated in large cities due to the increased temperatures (urban heat island) and larger population densities.**
- **These city effects may also impact neighboring areas.**
- **Our goal is to explore what impacts New York City might have on weather in Long Island during a heat wave event using the state of the art Weather and Forecast Research (WRF).**

Model Configuration

- **Advanced Research WRF version 3.5.1**
- **NARR used as initial and boundary conditions**
- **Three model-runs for each extreme weather case:**
- **WRF w/ Noah Land Surface Model (control case)**
- **WRF w/ Noah LSM + change urban land cover to forest (forest case)**
- **uWRF: WRF w/BEP-BEM (BEPBEM case)**
- **For the forest case, soil moisture adjusted for the original urban grid points for better representation of the land cover adjustment.**

Modeling Methods



3 nested domains:

a. Outer (D01):
   1071 km x 1071 km
   dx = 9 km

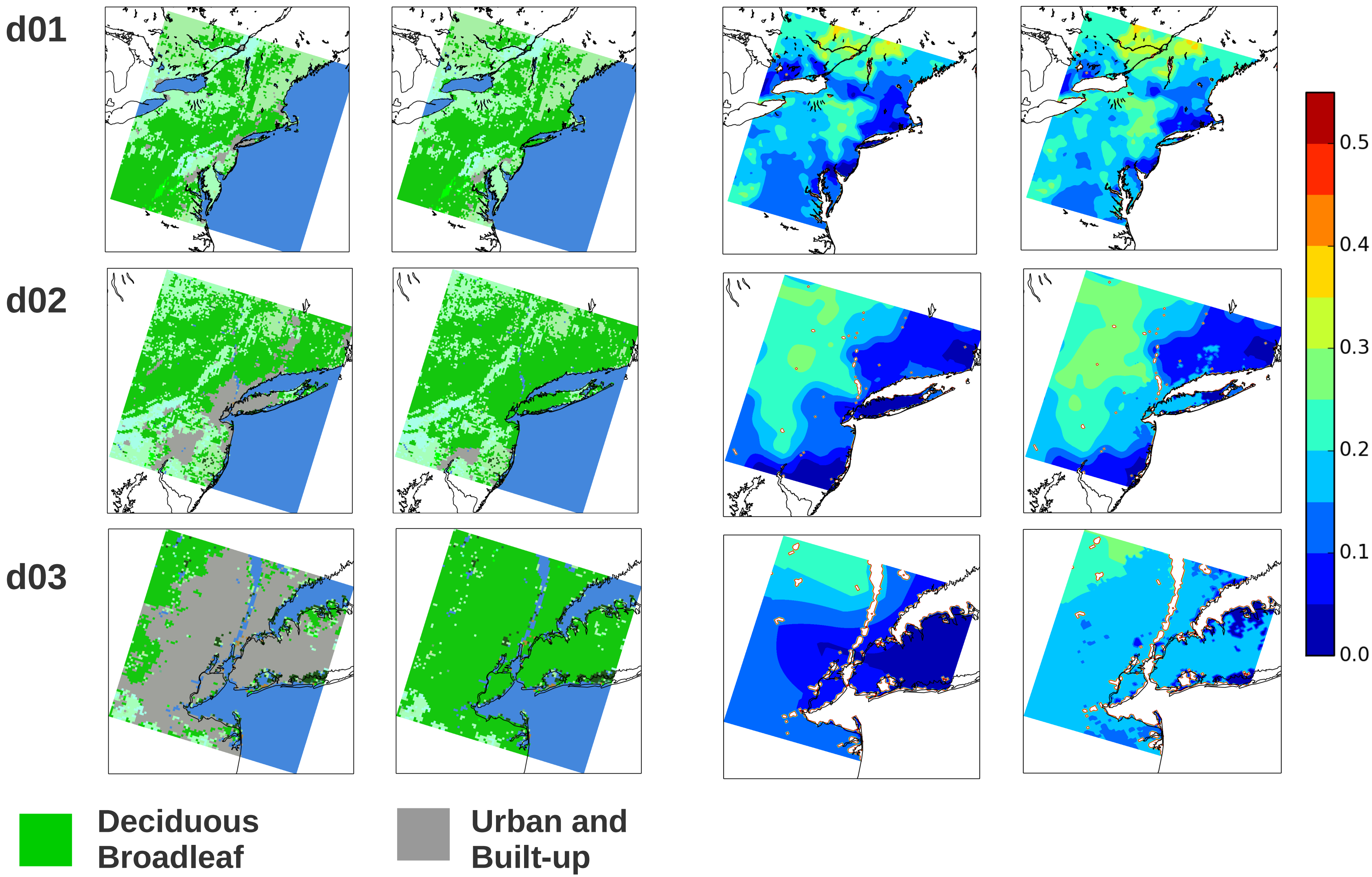
b. 1st nest (D02):
   360 km x 360 km
   dx = 3 km

c. 2nd nest (D03):
   90 km x 90 km

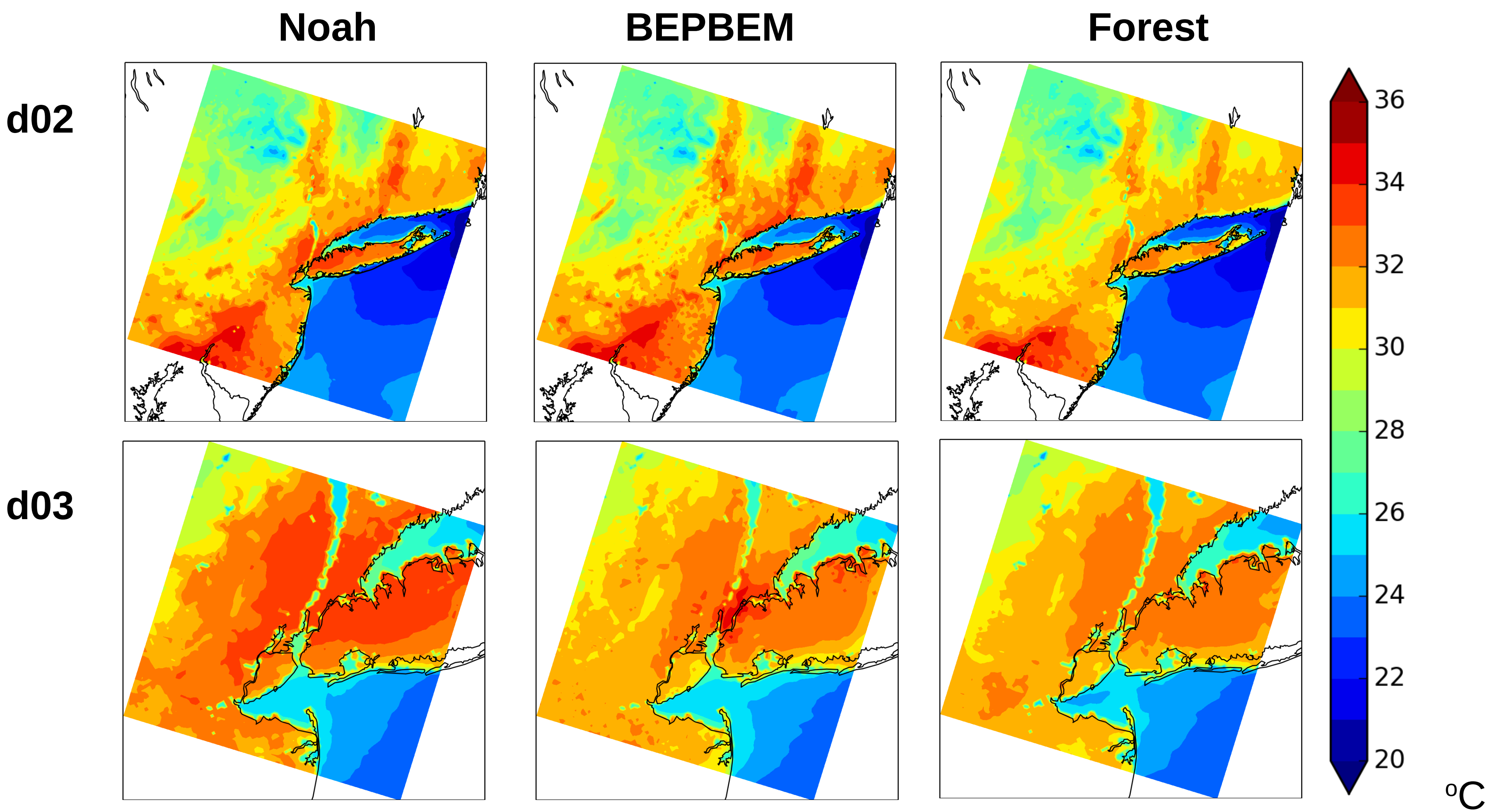
Model Physics

Physics Option	d01	d02	d03
Grid Size (km)	9	3	1
Microphysics	--	--	WSM6
Cumulus	Kain-Fritsch	Kain-Fritsch	--
PBL	BouLac	BouLac	BouLac
LW Radiation	RRTM	RRTM	RRTM
SW Radiation	Dudhia	Dudhia	Dudhia
Land Surface	Noah	Noah	Noah
Urban Param.	Noah	Noah	BEP-BEM

MODIS Urban Land Cover and Soil Moisture Adjustments

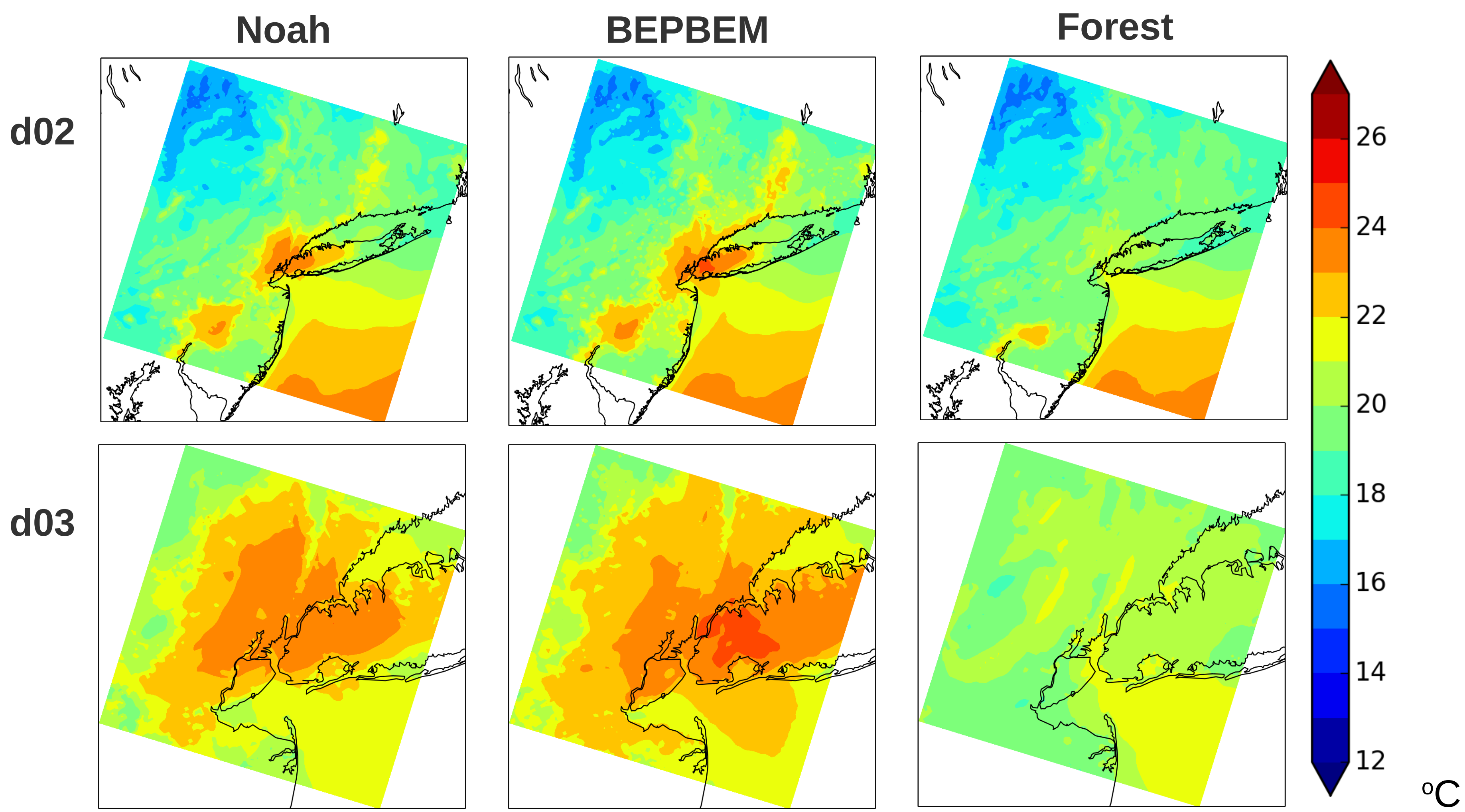


Daily Maximum Temperature



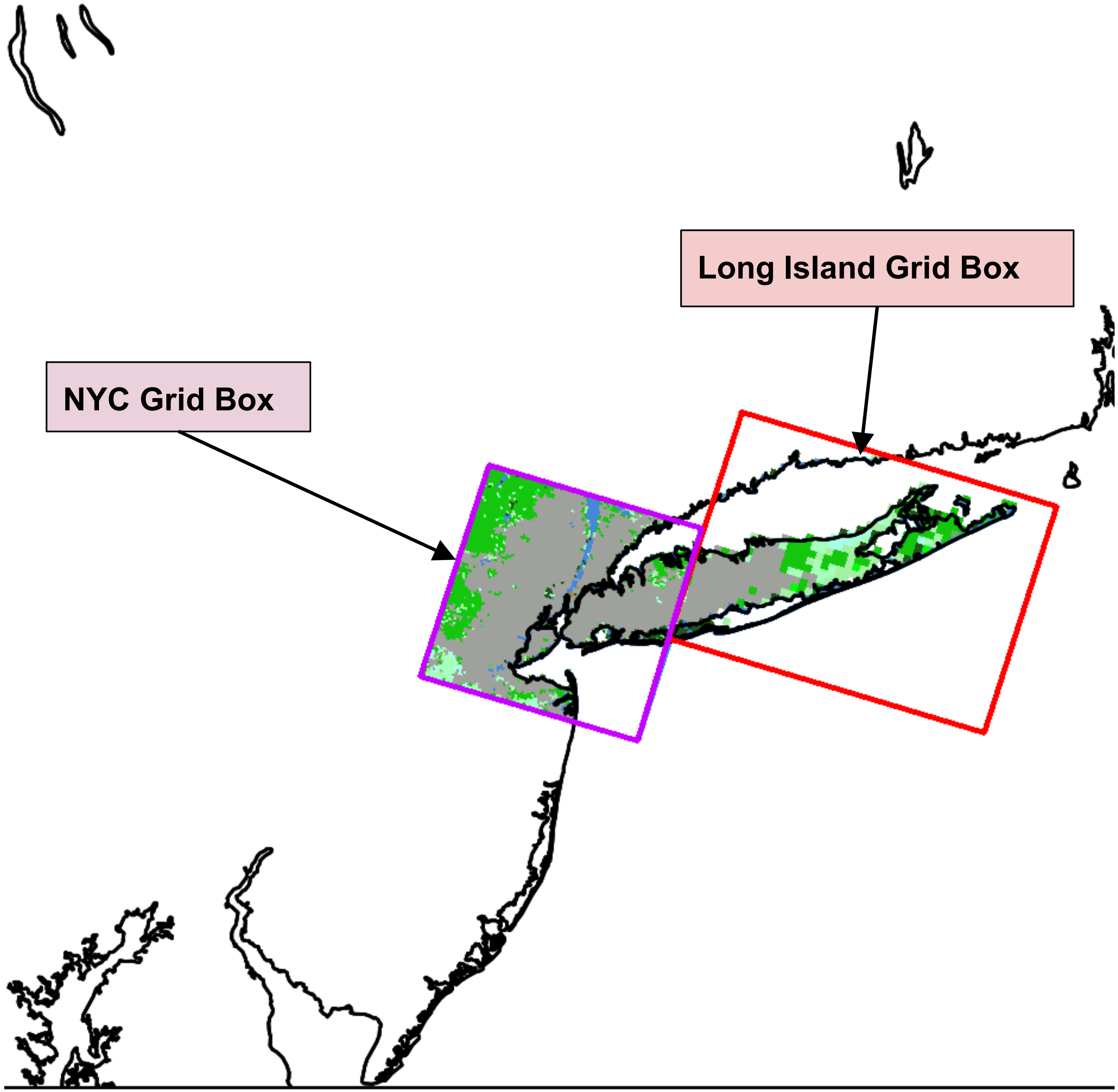
Noah case shows higher temperatures overall over NYC, while BEPBEM shows a warmer core over Manhattan and parts of the outer boroughs

Daily Minimum Temperature

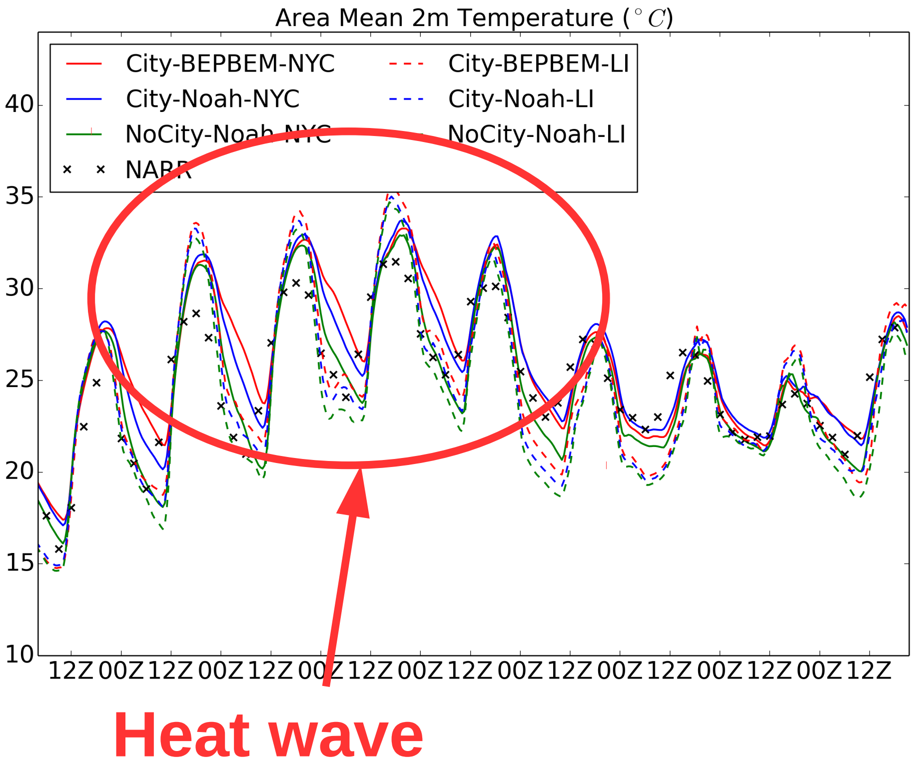


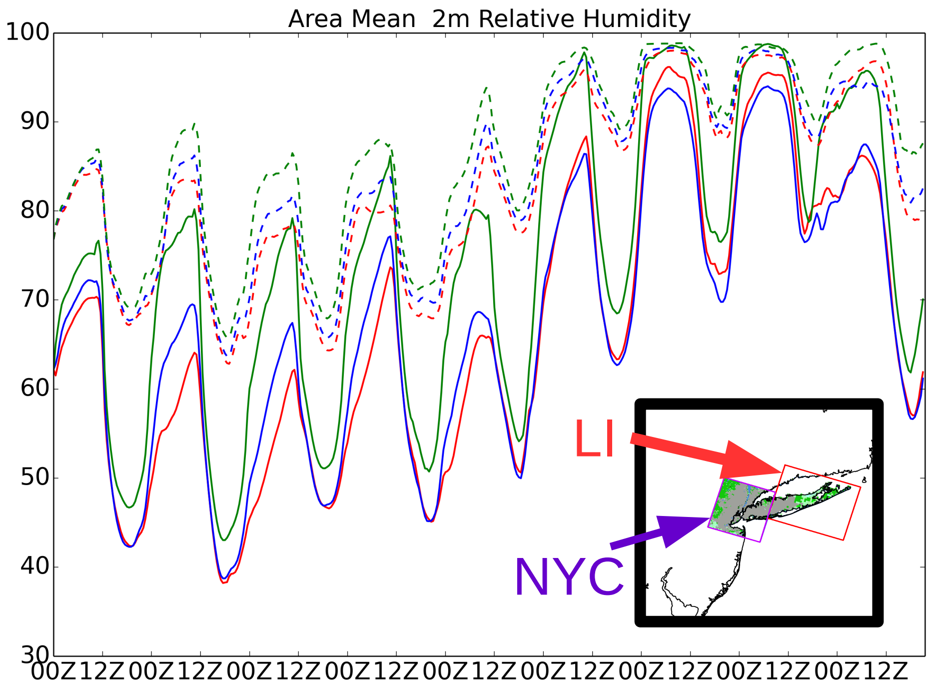
UHI signal much larger at nighttime. In forest case, UHI completely disappears. BEPBEM captures warm core over Manhattan/Brooklyn/Queens

Heat wave Analysis Domains



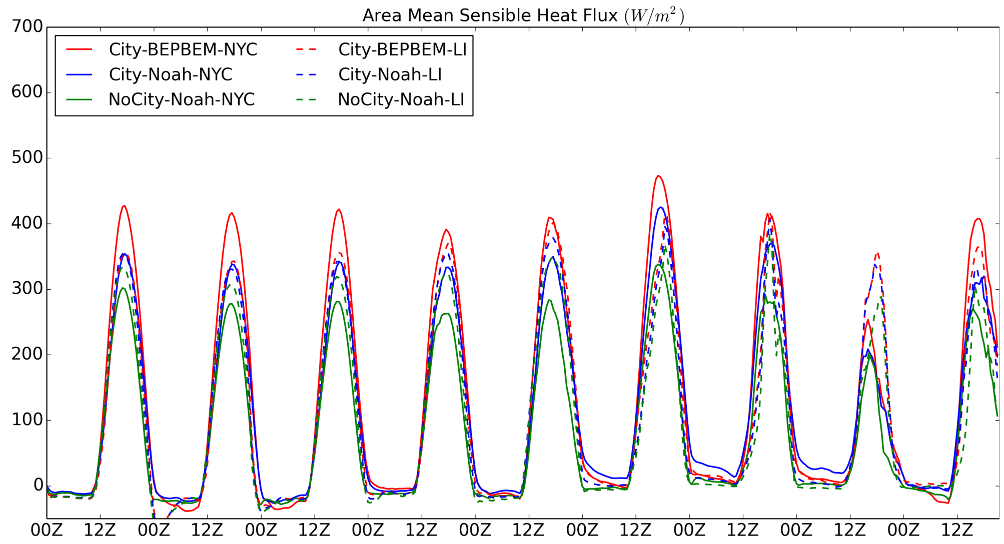
NYC and LI heat wave evolution

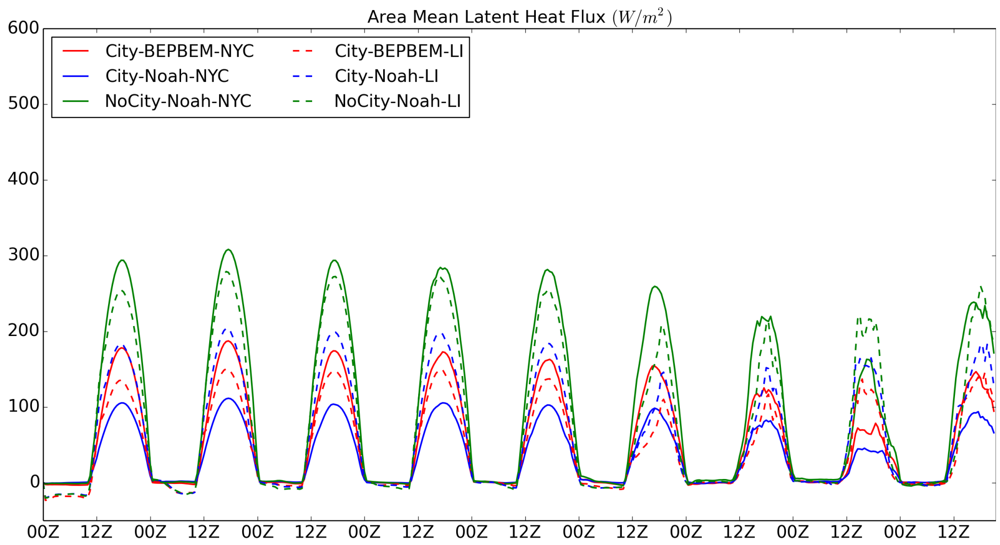




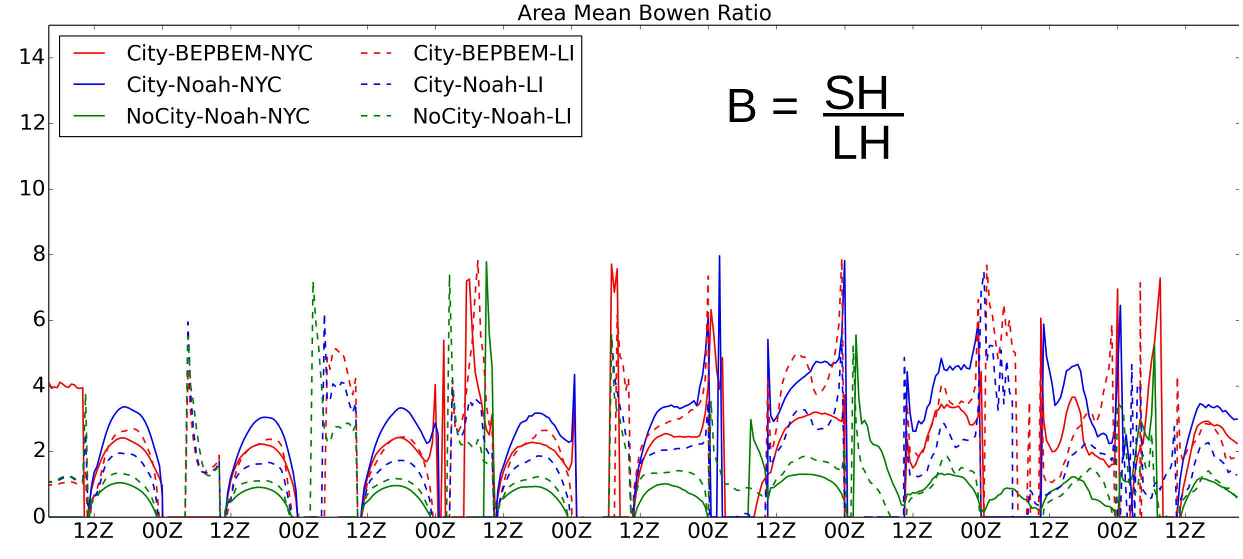
Not much difference in daily maximums. However, minimums show higher variability between cases. The Long Island region shows lower temperatures (by up to ~1.5 °C in forest case. Variability is due to lack of urban effects from NYC.

Surface Fluxes



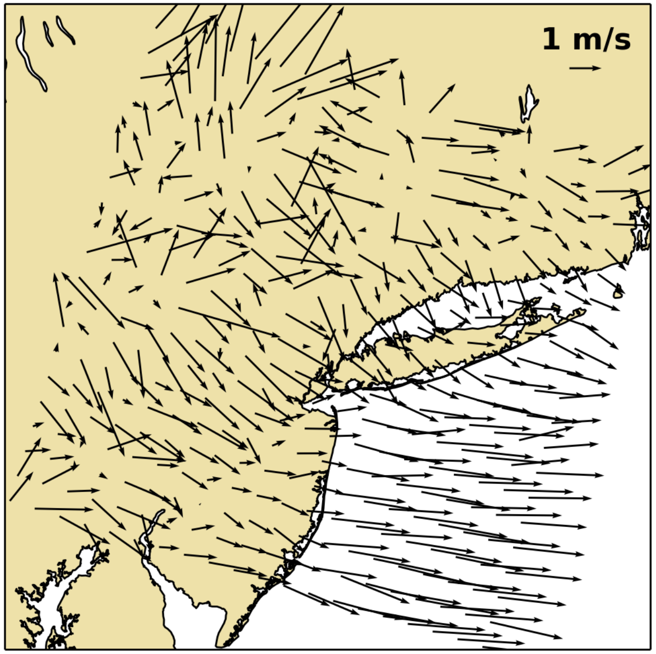


Sensible heat values are higher in the BEPBEM simulation due to increased anthropogenic heating from buildings. Latent heating in all cases is larger by up to 50% in both domains due to the added availability of soil moisture for evaporation.

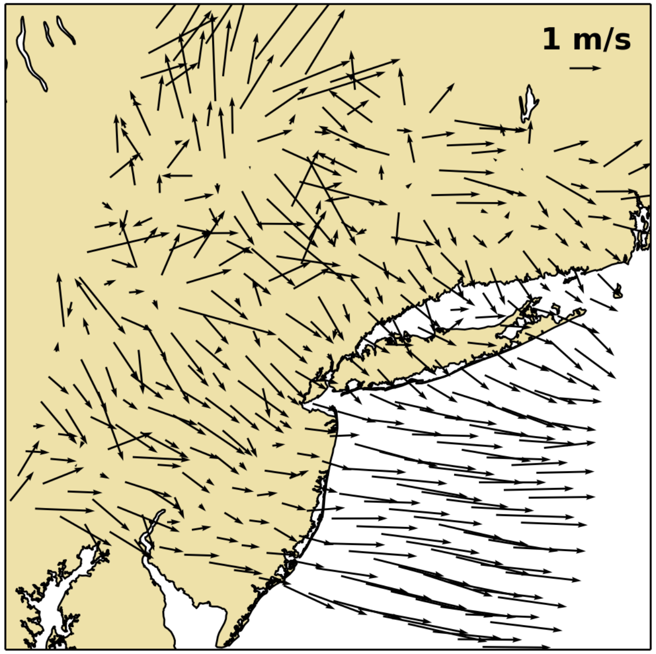


Mean Nighttime Winds (10Z)

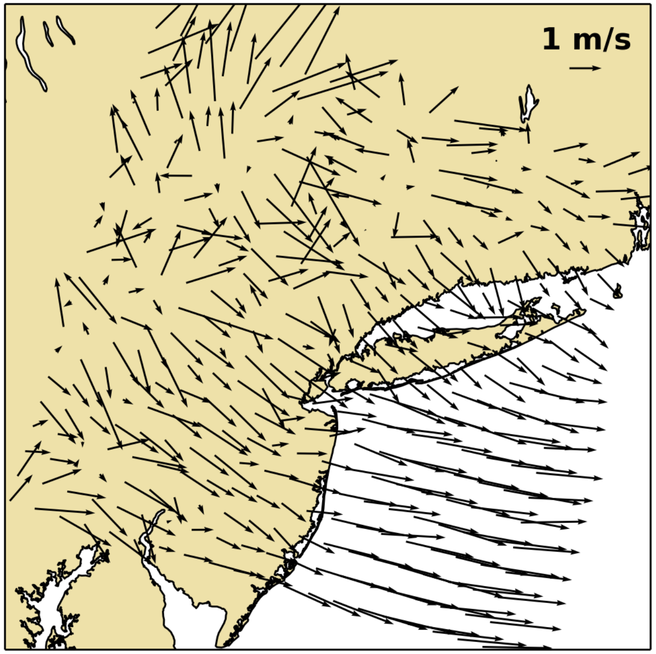
Noah



BEPBEM



Forest



Winds at time where minimum temperatures occur. The wind direction goes from island towards the east. Warm air from the city could be advected into Long Island, accounting for slight increases in nighttime temperature.

Summary

- A set of WRF simulations were run using three different case scenarios based on the land cover.
- The heat wave event appears well represented, with the timing and magnitude of the daily maximum temperatures captured. The sensitivity of the Long Island region to land cover over NYC is more notable at night, with differences between 1 and 2 degrees Celsius observed between the forest and BEPBEM cases.
- Future work will include wind analysis to see urban effects as related to advection. Surface station analysis will also be performed.

Future Work

- How was energy consumption affected by the heat wave in both NYC and LI?
  - Use building energy results from BEPBEM and compare to reported figures for NYC
- Are results from this heat wave typical of similar events?
  - Repeat experiment with other heat wave cases and compare results.

Questions?